Remarks

Claims 1-23 were pending in the subject application. By this Amendment, claim 15 has been amended, claims 22 and 23 have been cancelled, and new claims 27 and 28 have been added. Support for the new claims and amendments can be found throughout the subject specification and in the claims as originally filed. Entry and consideration of the amendments presented herein is respectfully requested. Accordingly, claims 1-21, 27, and 28 are currently before the Examiner for consideration. Favorable consideration of the pending claims is respectfully requested.

As an initial matter, Applicants note that the Office Action indicates the subject application is the national phase of international application PCT/KR02/01853 which claims priority from Korean application 2002/59612. This is incorrect. The subject application is the national stage of PCT/GB2003/003967 which claims priority to Great Britain application 0221393.2.

Claims 15 and 16 are rejected under 35 USC §112, second paragraph, as indefinite for lack of antecedent basis of the terms "sealing material." By this Amendment, Applicants have amended claim 15 to depend from claim 13. Claim 13 provides antecedent basis for the term "sealing material." Accordingly, reconsideration and withdrawal of the rejection under 35 USC §112, second paragraph, is respectfully requested.

Claims 1, 4, 7, 19, and 20 are rejected under 35 USC §102(b) as anticipated by Alberti *et al.* (U.S. Patent No. 5,453,172). Applicants respectfully traverse this ground of rejection.

Applicants respectfully assert that the Alberti *et al.* patent does not teach or suggest the claimed invention. As the Examiner is aware, in order to anticipate, a single reference must disclose within the four corners of the document each and every element and limitation contained in the rejected claim. *Scripps Clinic & Research Foundation v. Genentech Inc.*, 18 USPQ2d 1001, 1010 (Fed. Cir. 1991). Applicants respectfully assert that the Alberti *et al.* patent fails to teach each and every element of Applicants' claimed invention.

The Alberti *et al.* patent describes a solid-state sensor comprising a solid-state reference electrode in contact with a solid electrolyte (described by the Alberti *et al.* patent as a protonic conductor). A catalytic electrode (sensor electrode) is applied to the solid electrolyte on its surface opposite to the reference electrode. The Alberti *et al.* patent describes Ti-based or Zr-based

reference electrodes. The Alberti *et al.* patent describes a range of solid electrolytes such as uranyl hydrogen phosphate, antimonic acid, phosphomolybdic acid, zirconium hydrogen phosphate and dizirconium triphosphate in hydrogen form (see column 3, lines 19 to 23, of the Alberti *et al.* patent). Pt or Pa are proposed for the sensor electrode.

The Alberti *et al.* patent describes (see from column 3, line 54 onwards) the preparation of a solid-state sensor. First, a TiH or ZrH reference material is prepared. This is achieved by "heating a thin sheet of Ti or Zr... at a temperature... from 400°C to 700°C, for a time... of from two to 10 hours, in the presence of hydrogen gas" (see column 3, lines 47 to 53). The solid electrolyte is then applied to or coated onto the reference material, so that the reference material forms the reference electrode (see column 3, lines 65 to 67). The free face of the solid electrolyte is then coated with Pt or Pa (see column 4, lines 1 to 3). As described in the Examples in columns 5 and 6 of the Alberti *et al.* patent, the sensor can be used to detect hydrogen concentration at temperatures of, for example, room temperature (see Example 8), 100°C (see Example 5) or 200°C (see Example 6). However, the sensors would not be capable of operation at temperatures higher than these because the solid electrolyte materials (the protonic conductors) described in the Alberti *et al.* patent are not stable at such temperatures.

Example 9 in the Alberti *et al.* patent describes a sensor using a Nafion membrane as the solid electrolyte (protonic conductor), which must be kept constantly damp during measurement (see column 6, lines 42 and 43). Again, therefore, the sensor described in the Alberti *et al.* patent is for low-temperature use only.

As noted by the Examiner, the Alberti *et al.* patent mentions temperatures of 400°C to 700°C (see column 3, line 51), 500°C (see column 5, line 35 and line 58) and 650°C (see column 6, line 16). However, all of these temperatures are referenced in regard to the preparation of a TiH or ZrH reference electrode only, before the application of the solid electrolyte (protonic conductor). Thus, it is to be understood that these temperatures are not sensor operating temperatures.

Claim 1 in the subject application is directed to an apparatus for measuring hydrogen concentration comprising a proton-conducting solid electrolyte in conjunction with, or in contact with, a self-contained, sealed, metal/hydrogen reference standard. The Alberti *et al.* patent does not teach or suggest at any point the step of sealing the reference standard, or the reference electrode.

Further, claim 1 states that the content and/or the spatial distribution of oxygen in the reference standard, or reference electrode, is predetermined to render the solid electrolyte substantially chemically stable in the presence of the reference material. The Alberti *et al.* patent does not teach or suggest the oxygen content or the spatial distribution of oxygen in the solid-state reference electrode at any point. Thus, Applicants respectfully assert that claim 1 is not anticipated by the Alberti *et al.* patent because the Alberti *et al.* patent does not teach each and every element of claim 1.

Referring to the Alberti *et al.* patent, the Examiner states, in paragraph 8 of the Office Action, that "the electrode is prepared in a hydrogen environment... and, as shown in Example 8, is shown to have a constant partial pressure, making the electrode stable." The Examiner gives this as a reason for the Alberti *et al.* patent anticipating claim 7, which recites that the reference standard of the invention has bulk oxygen content that is sufficiently high to prevent reaction between the solid electrolyte and the reference material. Example 8 of the Alberti *et al.* patent describes a sensor comprising a reference electrode of TiH and a solid electrolyte of a polymeric organic ion-exchange membrane, and concludes that "Tests carried out at room temperature with N_2/H_2 mixtures (Figure 8) showed that the E.M.F. of the sensor, ... is a linear function of the logarithm of hydrogen partial pressure..." However, Example 8 does not state, as is alleged by the Examiner, that the electrode is "stable." Figure 8 of the Alberti *et al.* patent does demonstrate that the sensor operates to measure hydrogen concentration in N_2/H_2 mixtures at room temperature, but it does not state whether or not, as required by claim 1, the content and/or the spatial distribution of oxygen in the reference standard is predetermined to render the solid electrolyte substantially chemically stable in the presence of the reference material. Example 8 of the Alberti *et al.* patent does not even state that the solid electrolyte is substantially chemically stable in the presence of the reference material at all. The only possible conclusion that might be drawn from the Alberti *et al.* patent is that the sensor is able to survive the five readings shown in Figure 8, taken at room temperature. In contrast, and as is clear from the subject application, problems arise in such solid-state sensors as the operation temperature increases. Thus, there is no need to predetermine the content and/or the spatial distribution of oxygen in the solid electrolyte of the Alberti *et al.* patent, since the sensors of the Alberti *et al.* patent are only described as operating at temperatures between room temperature (Example 8) and 200°C

(Example 6). As described in the subject application, the problem of chemical reaction between the solid electrolyte and the reference standard or reference electrode does not arise at temperatures below 200°C. Thus, the Alberti *et al.* patent does not teach or suggest each and every element of claim 1 or claims dependent therefrom (including claim 7) and, thus, does not anticipate Applicants' claimed invention.

Applicants note that new claims 27 and 28 have been added by this Amendment. New claim 27 recites that the apparatus of claim 1 operates above 500°C. Support for new claim 27 can be found, for example, at page 11, line 10, of the subject application. New claim 28 further distinguishes between the claimed invention and the Alberti *et al.* patent. New claim 28 specifies that the solid electrolyte in the claimed invention as being oxide-based. Support for new claim 28 can be found, for example, at page 4 line 30, of the subject application. The electrolyte in Example 8 of the Alberti *et al.* patent is a polymeric organic ion-exchange membrane, and is therefore not oxide-based.

At the end of paragraph 8 of the Office Action, the Examiner states that the Alberti *et al.* patent "discloses the treatment of the sensor in the temperature range of 400°C - 700°C, for two or more hours, and therefore anticipates Claim 20." As noted previously herein, the Alberti *et al.* patent does not disclose treatment of the sensor at these temperatures. Rather, the Alberti *et al.* patent discloses heating of Ti or Zr sheets in hydrogen gas at temperatures between 400°C and 700°C, for two or more hours (see column 3, lines 47 to 53). This is not treatment of the sensor but rather is only treatment of the Ti or Zr sheet used to form the reference material, or reference electrode. After this preparation of the reference electrode, the remainder of the sensor is constructed. As described above, the sensors of the Alberti *et al.* patent are only exposed, after construction, to temperatures of 200°C or less, *i.e.*, the sensors are not exposed to a temperature of greater than 200°C. This is clear because the solid electrolytes proposed by the Alberti *et al.* patent would not survive at such higher temperatures.

As can be understood from the above, the Alberti *et al.* patent fails to teach or suggest each and every element of Applicants' claimed invention. Thus, the Alberti *et al.* patent does not anticipate the claimed invention. Accordingly, reconsideration and withdrawal of the rejection under 35 USC §102(b) is respectfully requested.

Claims 2, 3, 8-10, and 13 are rejected as obvious under 35 USC §103(a) over Alberti *et al.* (U.S. Patent No. 5,453,172) in view of Kiode *et al.* (U.S. Patent No. 5,445,725). Claims 5 and 6 are rejected as obvious under 35 USC §103(a) over Alberti *et al.* (U.S. Patent No. 5,453,172) in view of Wetch *et al.* (U.S. Patent No. 4,127,443). Claims 11, 12, 18, 21, and 23 are rejected as obvious under 35 USC §103(a) over Alberti *et al.* (U.S. Patent No. 5,453,172) in view of Tiwari (U.S. Patent No. 4,882,032). Claim 14 is rejected as obvious under 35 USC §103(a) over Alberti *et al.* (U.S. Patent No. 5,453,172) and Kiode *et al.* (U.S. Patent No. 5,445,725) in view of Ferro (2008). Claims 15 and 16 are rejected as obvious under 35 USC §103(a) over Alberti *et al.* (U.S. Patent No. 5,453,172) and Kiode *et al.* (U.S. Patent No. 5,445,725) in view of Bode (U.S. Patent No. 4,174,258). Claims 17 and 22 are rejected as obvious under 35 USC §103(a) over Alberti *et al.* (U.S. Patent No. 5,453,172) in view of Zupancic *et al.* (U.S. Patent No. 4,664,757). Applicants respectfully traverse these grounds of rejection.

Applicants respectfully assert that the cited references, whether taken alone or in combination, do not teach or suggest Applicant's claimed invention. Applicants hereby incorporate, in regard to all of the §103 rejections, their remarks regarding the Alberti *et al.* patent submitted herein in respect of the §102 rejection. In regard to claims being rejected as being obvious over the Alberti *et al.* patent in view of the Koide *et al.* patent (US 5,445,725), Applicants respectfully assert that the Koide *et al.* patent does not cure or overcome the failings of the Alberti *et al.* patent. In the paragraph bridging pages 5 and 6 of the Office Action, the Examiner states that the Koide *et al.* patent teaches the use of a molten electrode (see column 1, lines 54 to 68), which degrades the electrolyte layer over time. However, Applicants respectfully assert that the Koide *et al.* patent describes an entirely solid-state sensor including only solid electrodes. The Koide *et al.* patent does not describe a molten electrode. The only liquid phase mentioned by the Koide *et al.* patent is molten metal in which the concentration of hydrogen is being measured. The sensor of the Koide *et al.* patent comprises, as described at column 2, lines 11 to 26, a solid electrolyte with, on its inner surface, a reference electrode constituted of a porous electrode and, on its outer surface, a measuring electrode constituted of a porous electrode. Both of the electrodes and the electrolyte are solid at all times during use of the sensor. The electrodes are made of, for example, Pt, Ni or a conductive oxide (see column 6, line 19). In the Koide *et al.* patent, the reference standard, or reference material, is

provided by hydrogen gas supplied within the sensor structure. The problem described by the Koide *et al.* patent at column 1, lines 54 to 68, is that if such a sensor is used for measuring hydrogen concentration in molten metal, particularly aluminium, and is dipped directly in the molten metal, an insulating oxide layer forms on the interface between the molten metal and the solid electrolyte and disturbs the measurement of hydrogen concentration. The solution of the Koide *et al.* patent to this problem is to add a cup structure to the end of the sensor so that, when it is dipped in molten metal, the molten metal does not contact the solid electrolyte and so no insulating oxide layer forms.

In the paragraph bridging pages 5 and 6 of the Office Action, the Examiner first states that the Koide *et al.* patent teaches the use of a molten electrode (as noted previously herein, Applicants respectfully assert that this is incorrect because Koide's electrodes are made of solid Pt, Ni or conductive oxides) and then states that reaction of "the molten liquid with the electrolyte establishes an oxide layer." The Examiner goes on to state that "since the electrolyte of Alberti is used in its solid form, the degradation would not continue." However, all of the electrodes and the electrolytes in both the Koide *et al.* patent and the Alberti *et al.* patent are always in their solid form and, thus, there appears to be no basis for the Examiner's statement that "since the electrolyte of Alberti is used in its solid form, the degradation would not continue."

In the sensor of the Koide *et al.* patent, there are no molten components. Thus, referring to the use of Alberti's electrolyte in its solid form cannot solve any problem identified by the Koide *et al.* patent. In fact, if the sensor of the Alberti *et al.* patent was dipped in molten metal, such as molten aluminium, the sensor would be destroyed because it is not capable of operating at such high temperatures. It is well settled in patent law that where the modification of a cited reference destroys the purpose or function of the invention disclosed in the reference, the references cannot be properly combined and, therefore, a *prima facie* case of obviousness is not established. *In re Gordon*, 221 USPQ 1125 (Fed. Cir. 1984).

The Examiner further states in the instant Office Action that "it would be obvious to form the oxygen rich layer, as described by the heating of Koide *et al.* during the creation of the electrode as described in Alberti *et al.* because due to the environmental conditions used to create the electrode, the oxide layer would form naturally in the presence of air." However, in the Koide *et al.* patent, the damaging insulating oxide layer formed on the solid electrolyte is not formed in the presence of air.

It is formed when the sensor is dipped beneath the surface of molten metal such as molten aluminium. In the Alberti *et al.* patent, the temperature range of 400°C to 700°C referred to by the Examiner is only applied in a hydrogen atmosphere and not in the presence of air. Thus, Applicants respectfully assert that the Alberti *et al.* patent and the Koide *et al.* patent do not teach or suggest that it would be advantageous to form an oxygen rich layer on the solid-state reference electrode, or reference standard, as claimed in the present invention. In fact, the Koide *et al.* patent teaches the formation of a damaging oxide layer, and thus teaches away from the formation of such layers. This is because the Koide *et al.* patent describes the formation of an oxide layer on the solid electrolyte, and not on the reference standard or reference material, as in claim 8. The Alberti *et al.* patent does not describe the formation of any oxide layers at all. An invention that contradicts the teachings and express expectations of the prior art has long been accepted as indicia of non-obviousness of an invention. The United States Supreme Court affirmed this principle when it found an invention patentable where the inventor went against the accepted teachings, which when taken together, would deter investigation into such a combination. *United States v. Adams*, 383 U.S. 39, 52 (1966). Thus, the Alberti *et al.* patent and the Koide *et al.* patent do not teach or suggest the apparatus of any of the claims, including claim 8, or claims 9 and 10, which specify particular methods for preparing the oxygen rich layer.

The other secondary references cited under the §103 rejections do not cure the deficiencies of the primary reference. Claim 21 is similarly patentable because it specifies that the solid electrolyte is substantially stable in the presence of the solid reference standard, or reference electrode and, as discussed above, this feature is not taught or suggested by any of the cited references. Claim 27 specifies that the sensor is for use in particular at temperatures higher than 500°C. The sensors described by the Alberti *et al.* patent would not survive at such temperatures and so could not possibly be considered substantially stable at such temperatures. Claim 28 specifies that the solid electrolyte is an oxide-based electrolyte, unlike the solid electrolytes described in the Alberti *et al.* patent. With such electrolytes, control of the oxygen level in the reference standard or reference electrode is particularly important, to maintain chemical stability of the electrolyte in the presence of the reference material or electrode.

As the Examiner is aware, in order to support a *prima facie* case of obviousness, a person of ordinary skill in the art must generally find both the suggestion of the claimed invention, and a reasonable expectation of success in making that invention, solely in light of the teachings of the prior art and from the general knowledge in the art. *In re Dow Chemical Co.*, 5 USPQ2d 1529, 1531 (Fed. Cir. 1988). One finds neither the suggestion, nor the reasonable expectation of success, of Applicants' claimed invention in the cited references. Thus, Applicants respectfully assert that the claimed invention is not obvious over the cited references. Accordingly, reconsideration and withdrawal of the rejections under 35 USC §103(a) is respectfully requested.

It should be understood that the amendments presented herein have been made solely to expedite prosecution of the subject application to completion and should not be construed as an indication of Applicants' agreement with or acquiescence in the Examiner's position.

In view of the foregoing remarks and amendments to the claims, Applicants believe that the currently pending claims are in condition for allowance, and such action is respectfully requested.

The Commissioner is hereby authorized to charge any fees under 37 CFR §§1.16 or 1.17 as required by this paper to Deposit Account 19-0065.

Applicants invite the Examiner to call the undersigned if clarification is needed on any of this response, or if the Examiner believes a telephonic interview would expedite the prosecution of the subject application to completion.

Respectfully submitted,

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